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FAINT C AND O RECOMBINATION LINES IN H II REGIONS AND LARGE TELESCOPES: THE CASE OF S311

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We present preliminary results on the analysis of very deep echelle UVES (8m VLT) spectra of the Galactic H II region S311 (NGC 2467) located outside the Solar circle. The data cover from 3100 to 10450 Å with a resolution R$\sim$ 8800. We have detected and measured more than 300 emission lines, some of them are faint recombination lines of heavy–element ions. We have derived the O abundances from OI and OII recombination lines and the C abundance from CII lines and an Ionization Correction Factor (ICF). This kind of observations will permit us to derive the Galactic abundance gradient of C and O from nebular recombination lines, which are almost independent on the real temperature structure of the nebula.

Introduction

Derivation of precise abundance gradients in the Milky Way is essential to study the Galactic chemical evolution. Adquisition and analysis of deep high-resolution spectroscopy for a complete set of H II regions inside a suitable range of galactocentric distances is one of our main aims. In recent papers we have studied the chemical composition of several bright Galactic H II regions located inside a rather narrow interval of galactocentric distances (see García-Rojas et al. 2004, and references therein). For all these regions we have measured several recombination lines (RLs) of C and O ions. S311 is an H II region located outside the Solar circle at a galactocentric distance of 10.4 kpc (assuming the Sun at 8 kpc). This object extends our sample towards more external regions in the Galactic disk. This is the first time that ionic abundances of heavy-element ions have been derived from RLs for this object and for a so external HII region.

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TABLE 1

IONIC ABUNDANCES FROM RLS

Ion	Mult.	$\lambda(\AA)$	$I(\lambda)/I(H\beta)$ [$I(H\beta)$=100]	X^{+i}/H^{+} ($\times10^{-5}$)
C^{++}	6	4267.26	0.116	11±1
O^{+}	1	7771.94	0.020	24±9
O^{++}	1	4638.85	0.026	25
		4641.81	0.026	9
		4649.14	0.023	5
		4650.84	0.023	23
		4661.64	0.022	17
		Adopted		11±1

Physical Conditions

We have obtained an electron density of 330±70 cm^{-3} from [O II], [S II], [Cl III] line ratios, and from [Fe III] lines. A two-zone scheme (low and high ionization zones) has been assumed to compute the temperatures. From the [N II] and [O II] ratios we have obtained $T_e(low)$ = 9500±250 K, and from [O III] and [Ar III] ratios, $T_e(high)$ = 9000±200 K. From the Balmer and Paschen decrements we have computed T_e(Bac) = 9500±900 K and Te(Pac) = 8700±1100 K.

Ionic Abundances

Several recombination lines of C II, O I and O II have been measured in the spectra of S311. These lines are very convenient to derive the real abundance of the ions because they are almost independient of the temperature structure of the nebula. In Table 1 we show the derived abundances of C^{++}, O^{+} and O^{++}. We have used the recombination coefficients by Storey (1995) for O^{++}, by Péquignot, Petitjean & Boisson (1991) and Escalante & Victor (1992) for O^{+} and by Davey, Storey & Kissielius (2000) for C^{++}.

Temperature fluctuations

Due to the different O^{++}/H^{+} ratios obtained using Collisionaly Excited Lines (CELs) or Recom-

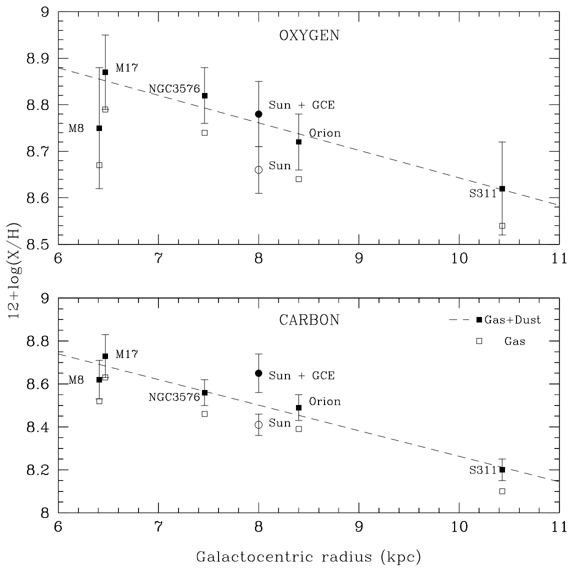

Fig. 1. Galactic O and C radial abundance gradients from H II region abundances determined from recombination lines. Sun+GCE are the values expected for the Interstellar medium at the solar Galactocentric distance. Galactocentric distances are from Russeil (2003)

bination Lines (RLs) (12+log $O^{++}/H^+ = 7.81$ and 8.03 respectively) we hace derived the *mean square temperature fluctuations,* t^2, that would produce the agreement between both determination, which is 0.035. On the other hand, t^2's obtained from comparing $T(Bac)$ and $T(Pac)$ with the temperatures obtained from forbidden line ratios are much lower. A first look to synthetic spectra generated using parameters obtained from atmosphere modelling of HD64315 –the main source of ionization of S311– reveals that Balmer and Paschen jump are of the order of 10% and 3% respectively. An estimation to the relative contribution of the underlying dust-scattered stellar continuum to the total continuum is needed.

Total Abundances and abundance gradients

We have derived total abundance of O by adding O^+/H^+ and O^{++}/H^+ abundance ratios, and of C by applying an ionization correction factor (ICFs) from Peimbert, Torres-Peimbert & Ruiz (1992) to correct for the unseen C^+/H^+.

In Figure 1 we have represented a preliminary Galactic O and C radial abundance gradient from H II region abundances determined from RLs. The fits are for dust+gas abundances, which were derived assuming that the fraction of O and C embebbed in dust grains is the same for S311 than in Orion nebula. Therefore, following Esteban et al. (1998) we have added 0.08 and 0.10 dex to the gaseous O and C abundances. We have derived C/H, O/H and C/O Galactic radial abundance gradients of -0.119 ± 0.019, -0.059 ± 0.029 and -0.060 ± 0.035, respectively.

The near future and GTC

Deep intermediate and high-resolution spectra of bright Galactic H II regions are essential for a better understanding of the intimate secrets of ionized nebulae. We really need to understand why abundances from RLs are sistematically higher than those obtained from CELs, and whether this fact is related with the presence of temperature fluctuations. This is very important because most of our knowledgement about the chemical composition of the extragalactic universe resides in the analysis of CELs in ionized nebulae. We need further observations of Galactic and extragalactic HII regions. In this sense, the projected capabilities of intermediate-resolution spectroscopy with OSIRIS (or the echelle spectrograph UES) at the GTC would permit to carry out these kinds of observations.

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